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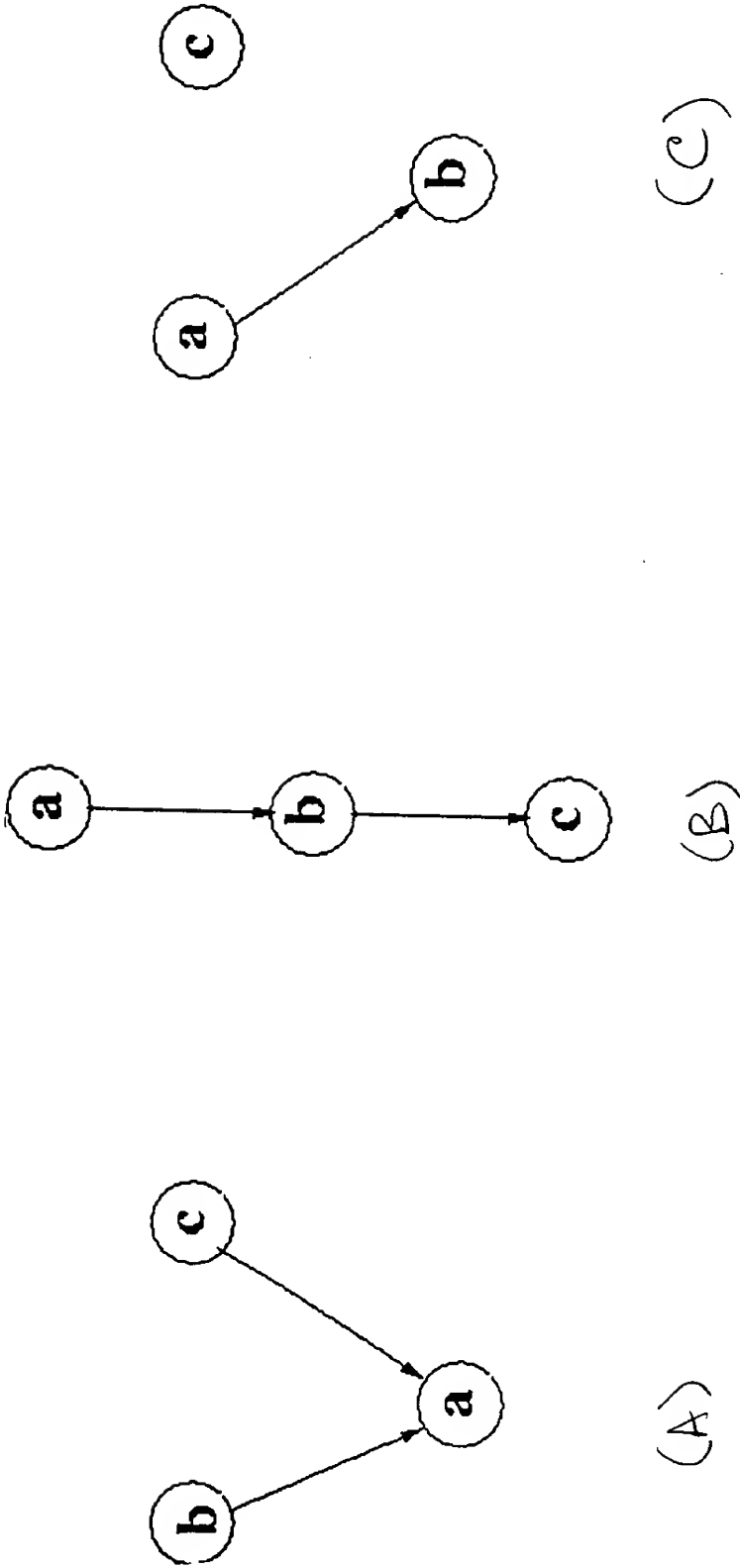


FIG. 1

T\_1: {a, b, c, d, e, f, g}

T\_2: {d, f, g}

T\_3: {a, b, d, g}

T\_4: {a, d, g}

T\_5: {f, g}

T\_6: {e, f}

T\_7: {e}

T\_8: {h, i}

T\_9: {h, j}

T\_10: {j}

102

| PATTERNS | COUNT |
|----------|-------|
| a        | 3     |
| b        | 2     |
| c        | 1     |
| d        | 4     |
| e        | 3     |
| f        | 4     |
| g        | 5     |
| h        | 2     |
| i        | 1     |
| j        | 2     |

104

| PATTERNS | COUNT |
|----------|-------|
| ab       | 2     |
| ad       | 3     |
| ae       | 1     |
| af       | 1     |
| ag       | 3     |
| .....    |       |

106

### Example for Dependency

{ag}: frequent, is not d-pattern with 95% confidence

$$p(a) = 3/10; p(g) = 5/10; p^* = 3/10 * 5/10 = 0.15$$

$$\text{minsup}(\{a, g\}) = 10 * 0.15 + 1.86 * \sqrt{10 * 0.15 * (1 - 0.15)} = 3.6$$

{ab}: is not frequent, but is d-pattern with 95% confidence

$$p(a) = 3/10, p(b) = 2/10, p^* = 2/10 * 3/10 = 0.06$$

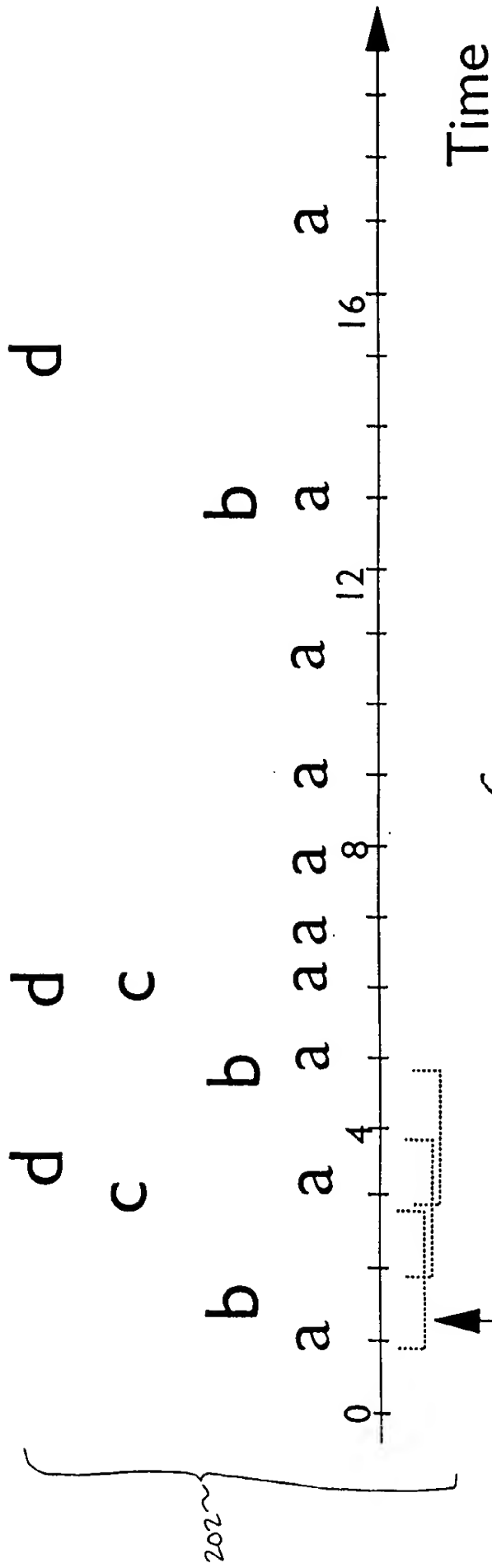
$$\text{minsup}(\{a, b\}) = 10 * 0.06 + 1.86 * \sqrt{10 * 0.06 * (1 - 0.06)} = 1.99$$

108

2/9

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FIG. 2A



Time

EXAMPLE FOR DEPENDENCY

TOTAL # OF SLIDING WINDOWS = 20

{ab}: frequent, but not d-pattern with 95% confidence

$$P(a) = 10/20; P(b) = 3/20; P^* = 10/20 * 3/20 = 0.075$$

$$\text{minsup}(\{ab\}) = 20 * 0.075 + 1.86 * \text{sqrt}(20 * 0.075 * (1 - 0.075)) = 3.69$$

{dc}: not frequent, but is d-pattern with 95% confidence

$$P(d) = 3/20; P(c) = 2/20; P^* = 3/20 * 2/20 = 0.015$$

$$\text{minsup}(\{dc\}) = 20 * 0.015 + 1.86 * \text{sqrt}(20 * 0.015 * (1 - 0.015)) = 1.3$$

208

Patterns Count

|     |   |
|-----|---|
| ab  | 3 |
| ac  | 2 |
| dc  | 2 |
| ... |   |

206

Patterns Count

|   |    |
|---|----|
| a | 10 |
| b | 3  |
| c | 2  |
| d | 3  |

204

FIG. 2B

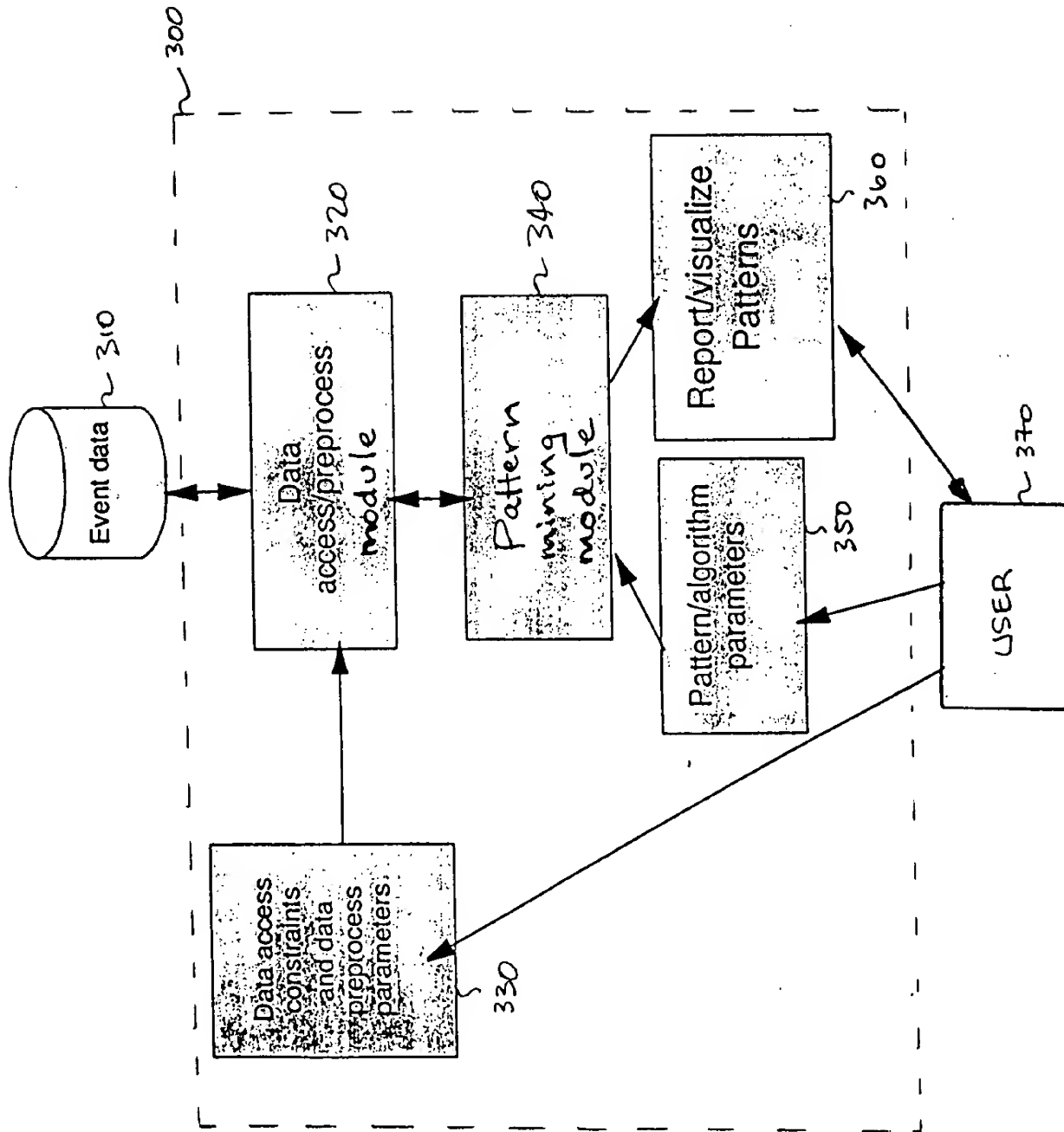
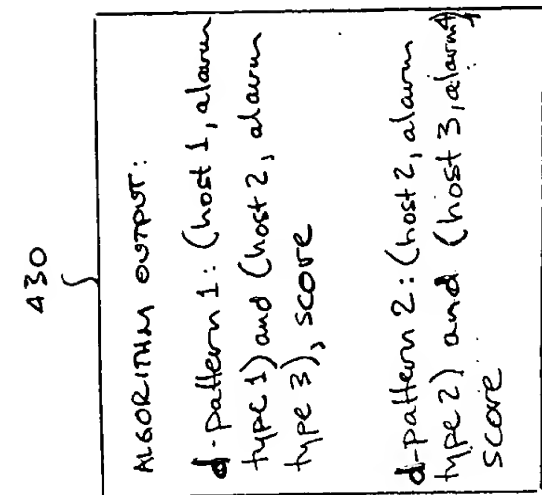


FIG. 3



410

| EVENT ID | HOST ID | EVENT TYPE ID | TIME STAMP |
|----------|---------|---------------|------------|
| 1        | 1       | 1             | 1          |
| 2        | 2       | 2             | 2          |
| 3        | 2       | 3             | 2          |
| 4        | 2       | 1             | 4          |
| 5        | 2       | 3             | 5          |
| 6        | 1       | 1             | 7          |
| 7        | 2       | 3             | 8          |
| 8        | 2       | 2             | 9          |
| 9        | 1       | 1             | 15         |
| 10       | 2       | 3             | 16         |
| 11       | 2       | 2             | 16         |
| 12       | 1       | 1             | 18         |
| 13       | 2       | 3             | 19         |
| :        | :       | :             | :          |
| :        | :       | :             | :          |

FIG. 4

500 ~

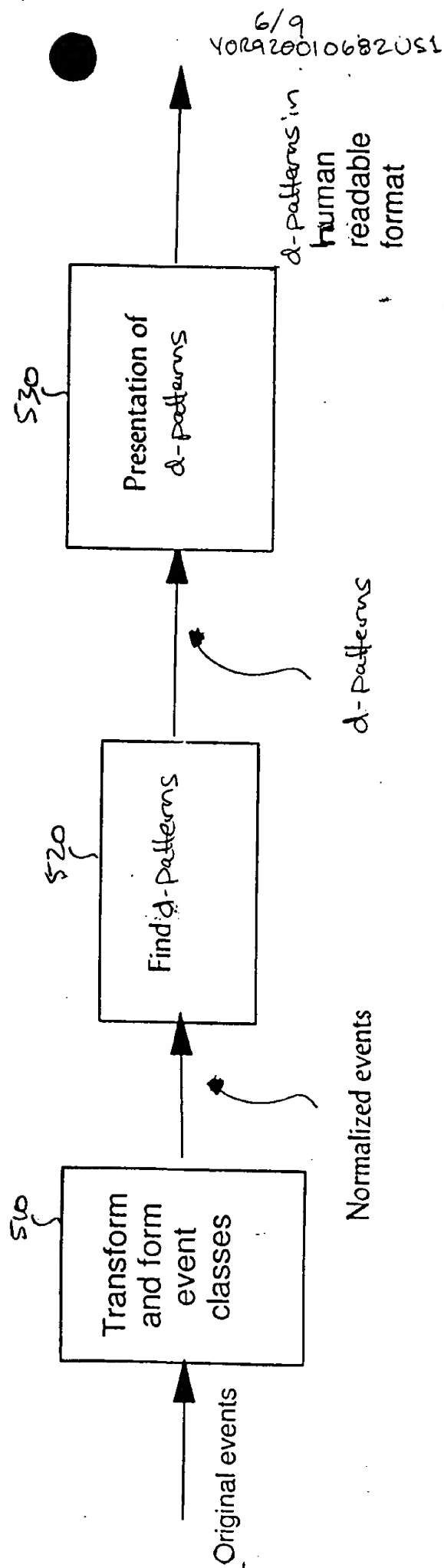


FIG. 5

610 ↗

| Event ID | Event type ID | Host ID | Time stamp |
|----------|---------------|---------|------------|
| 1        | 1             | 1       | 1          |
| 2        | 2             | 2       | 2          |
| 3        | 1             | 1       | 4          |
| 4        | 1             | 1       | 7          |
| 5        | 2             | 2       | 9          |
| 6        | 1             | 1       | 15         |
| 7        | 2             | 2       | 16         |
| 8        | 1             | 1       | 18         |
| 9        | 1             | 3       | 19         |
| 10       | 2             | 1       | 21         |
| 11       | 2             | 2       | 23         |
| 12       | 2             | 2       | 25         |
| 13       | 1             | 1       | 30         |

Table: original events



620 ↗

| {Event type ID, host ID} | Event class |
|--------------------------|-------------|
| {1, 1}                   | 1           |
| {1, 3}                   | 2           |
| {2, 1}                   | 1           |
| {2, 2}                   | 4           |

Table: mapping for event class

630 ↗

| EVENT ID | EVENT CLASS | TIME Stamp |
|----------|-------------|------------|
| 1        | 1           | 1          |
| 2        | 4           | 2          |
| 3        | 1           | 4          |
| 4        | 1           | 7          |
| 5        | 4           | 9          |
| 6        | 1           | 15         |
| 7        | 4           | 16         |
| 8        | 1           | 18         |
| 9        | 2           | 19         |
| 10       | 1           | 21         |
| 11       | 4           | 23         |
| 12       | 4           | 25         |
| 13       | 1           | 30         |

Table: event after mapping

FIG 6

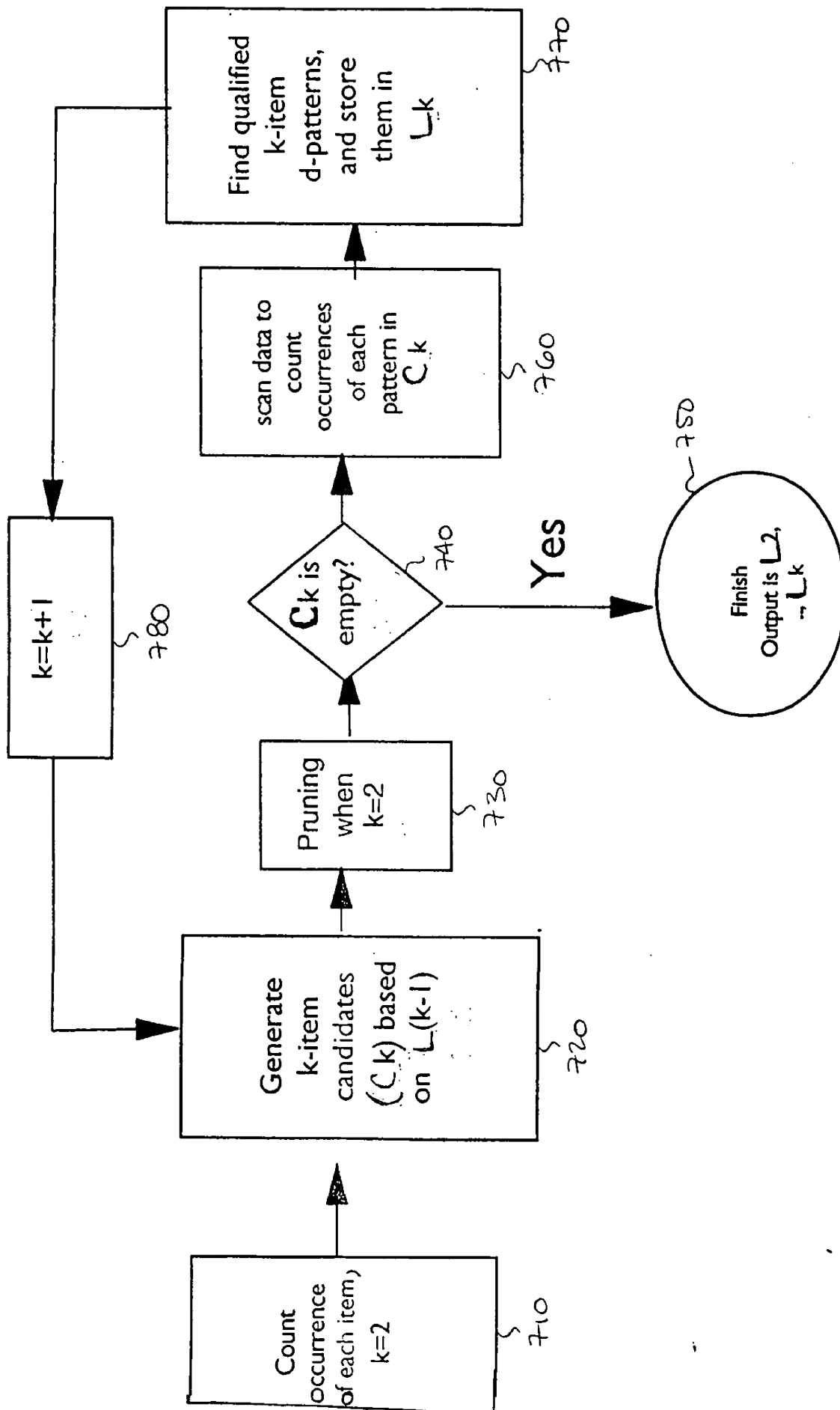


FIG. 7



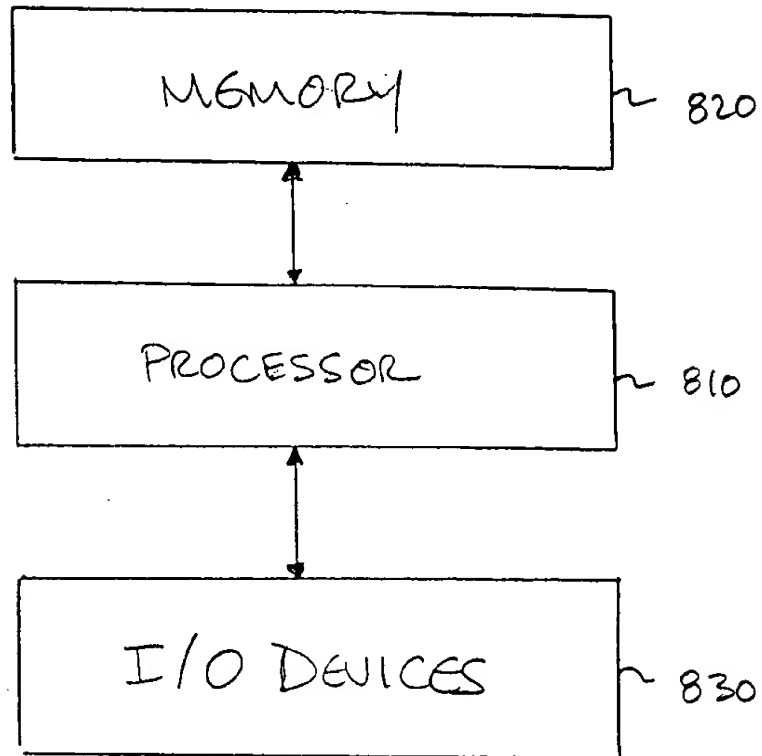


FIG. 8

FIG. 8